U. S. DEPARTMENT OF AGRICULTURE.

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THE USE OF PARIS GREEN IN CONTROLLING THE COTTON BOLL WEEVIL.

BY

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., December 5, 1904.

SIR: I herewith transmit a manuscript entitled "The Use of Paris Green in Controlling the Cotton Boll Weevil," prepared by Mr. W. D. Hunter, special agent of this Bureau in charge of the experimental work with the Mexican cotton boll weevil in Texas. On account of a widespread misunderstanding regarding the value of Paris green as a boll weevil remedy, it seems important that this manuscript should be published speedily and in a large edition. I therefore recommend that it be issued as a Farmers' Bulletin.

In the work leading to this bulletin, as well as in the preparation of the manuscript, the author has been materially aided by Dr. W. E. Hinds, principal assistant, as well as by Mr. J. C. Crawford, jr., who has been engaged upon the subject dealt with herein throughout the greater part of the season.

Respectfully,

L. O. HOWARD,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE USE OF PARIS GREEN IN CONTROLLING THE COTTON BOLL WEEVIL.

INTRODUCTION.

During the past season there has been a very extensive use of Paris green in an attempt to control the boll weevil in Texas. This has been due to several mistaken conceptions about the habits of the pest, as well as many misconstructions of the results of applications made in the field by various parties. It has been known for many years that it is possible to destroy a certain number of boll weevils by the use of Paris green, provided applications are made early in the season before any squares are set upon the plants. At this time the weevil feeds on the opening leaflets, and heavy applications of poison destroy a number of them. Many persons have thus killed a certain number of weevils and have concluded that the number found feeding upon the young plants having no squares represents the total number of weevils in the field. As a matter of fact, however, abundant observations have proven that a very great majority of weevils do not come from hibernating quarters until after the plants have begun to put on squares. This is shown in Table VI on a following page. After squares are formed upon the plants the weevils no longer feed upon the leaves, but puncture the squares, and are then beyond the reach of poison. It will be seen from the foregoing statements that early in the season a few weevils may be killed by the use of Paris green, and it is from this fact that the idea has taken hold of many farmers in Texas that in this poison they have a specific against the pest.

On account of the very great attention which has been called to the proposed method of controlling the boll weevil by means of Paris green the Department of Agriculture has devoted special attention to the matter. Experiments have been performed at different points in Texas upon the experimental farms of the Bureau of Entomology, in which care was taken to eliminate all disturbing factors and to obtain accurate information regarding the possibility of poisoning the weevil. In addition to this work, agents connected with this Bureau have visited practically all of the fields at which, at one time or another during the season, the owners have supposed that satisfactory results have been procured. The Bureau of Entomology has from time to time during the season warned the planters through the press against

placing too much dependence upon poison, but despite these warnings it is estimated conservatively that at least 25 carloads of Paris green have been used in Texas. The rather complete results of the work that has been conducted by the Bureau of Entomology are presented in the following pages. As a result of all that has been done by the Department, as well as the conclusion from careful examinations of many cotton fields in Texas, the Bureau of Entomology does not recommend the use of Paris green in an attempt to control the boll weevil.

The fact that applications of Paris green will kill a certain per cent of weevils upon treated plants has been known to the agents of the Bureau of Entomology for ten years. Its use through the medium of a spray was suggested as early as 1895 (Circular No. 6, new series) and repeated in 1897 (Circular No. 18, new series; Farmers' Bulletin No. 47) and in 1898 (Circular No. 33, new series). It was, however, recommended then only as a means of killing off some of the hibernated weevils before squares appeared on the cotton.

Through the repeated experiences of several seasons it had been found that spraying cotton with a solution of Paris green had no positive value in controlling the boll weevil throughout the season, and this conclusion has been generally accepted as well established. Therefore the work of the agents of the Bureau of Entomology with Paris green during the season of 1904 has been confined mainly to the application of the poison as a dry powder. Many claims have been made for the superiority of this method of using the poison and for its efficacy, when so used, as a remedy for the Mexican cotton boll weevil. Early in the spring of 1904 a comprehensive series of tests was begun upon areas sufficiently small to allow every plant to be thoroughly prepared, treated, and examined, so that as far as is possible in the field every weevil might be accounted for and the exact effect of the poison determined under the varying conditions of the test made.

Upon more extended areas the Bureau of Entomology has this year conducted field tests extending through the season. Checks were kept in these field tests and the results of the poisoning must be judged by a comparison of the crop records of poisoned and check areas, which in all other respects were intended to be under similar conditions and to receive identical treatment. In addition to the field results, determined by agents of this Bureau, the experience of a number of representative, practical planters has been drawn upon.

Whatever results might have been obtained upon small areas, it is evident that only results of actual field practice in various localities and by a number of men could ever demonstrate the advisability of adopting or rejecting the use of dry Paris green in the fight against the weevil.

EXPERIMENTS CONDUCTED BY THE U. S. DEPARTMENT OF AGRICULTURE.

TREATMENT OF SMALL AREAS, WITH CAREFUL EXAMINATIONS.

Conditions covered and methods employed.—In the following series of tests, in order that the number of weevils killed by the poison might be accurately determined, the plants to be treated were carefully examined to find the number of weevils present, disturbing them as little as possible. A tag bearing all necessary information regarding the conditions of the test and of the weevils was placed with each plant. Papers were then spread under the plants, extending considerably beyond the spread of the branches to catch the dead weevils. In spite of this precaution it was soon found that a large proportion of the weevils were missing when later examinations were made. As soon as this fact was observed weevils, so marked with colored pencils as to be positively identifiable, were used, the weevils so marked constituting over 76 per cent of the total number treated. The tests were conducted from April 19 to May 19, giving a range of weather conditions. These were varied by making applications on calm and on windy days, some early in the morning while the plants were wet with dew, others during the middle of the day when the plants were dry, some in the middle of the day but spraying the plants to give dew conditions. Plants with and without squares were treated, and in three of the tests plants used in the test immediately preceding were re-treated, together with the weevils surviving the previous test, thus making conditions as severe as was possible. In part of the tests the poison was applied with a powder gun, and in the remainder was used the method employed for many years in using Paris green against the cotton-leaf worm—of shaking the poison from a sack. An exceedingly heavy rate was used, since the object of the tests was to kill the weevil if it were possible to do so with Paris green.

Spraying.—On April 27 a test was made with a spray consisting of 1 pound of Paris green in 30 gallons of water, 49 plants with 94 weevils on them being thoroughly sprayed. At the last examination, made 72 hours after the application, 78 weevils were found alive, 5 dead, 11 missing; 82.97 per cent surviving. Since this test was not as successful as the tests with dry Paris green nothing further was done with the spray. On this point Prof. E. D. Sanderson (Farm and Ranch, October 8, 1904, p. 16) says:

> The dry dust also seems to kill the weevils somewhat more quickly, though in the liquid form the poisons are just as fatal.

Poison blown by a powder gun.—The plants were dry when treated in three of these tests, and the powder was blown in from all directions. Four tests (Table I, Nos. 1, 2, 3, 5) were conducted on seppa

plants without squares. The application of poison, though not measured, was heavy in comparison with those tests in which the poison was sifted from a sack, so that it must have been much heavier than at the rate of 20 pounds per acre (as conservatively stated in Table I). The total number of weevils used was 173. The average time elapsing between the application and the last examination was 48 hours. The number of weevils found alive in the four experiments was 37.49 per cent, dead 39.94 per cent, and missing 22.62 per cent of the total number treated.

TABLE I.—*Results of treatment of cotton plants with dry Paris green.*

Experiment No.	Date Paris green applied.	Number of plants used.	Rate of Paris green per acre in pounds for plants 2 by 4 feet apart.	Number of weevils used.	Number of examinations.	Number of hours elapsed at time of last examination.	Number of weevils found alive.	Number of weevils found dead.	Number of weevils missing.	Per cent of weevils found alive.	Per cent of weevils found dead.	Per cent of weevils missing.
1 ..	Apr. 19	23	20	26	1	28	6	10	10	23.07	38.46	38.47
2 ..	Apr. 25	25	20	38	3	62	17	14	7	44.73	36.84	18.63
3 ..	Apr. 26	45	20	70	2	44	27	34	9	38.57	48.57	12.86
5 ..	Apr. 28	31	20	39	1	57	17	14	8	43.59	35.89	20.52
6 ..	May 13	25	20	60	1	20	31	7	22	51.66	11.66	36.68
7 ..	May 14	25	20	56	1	44	8	11	37	14.28	19.62	66.10
8 ..	May 16	41	$45\frac{10}{16}$	88	1	42	13	13	62	14.77	14.77	70.46
9 ..	May 17	31	$32\frac{15}{16}$	87	1	65	10	31	46	11.49	35.63	52.88
10 ..	May 18	37	$20\frac{11}{16}$	80	1	41	25	36	19	31.25	45.00	23.75
11 ..	May 19	39	41	95	2	96	21	23	51	21.25	24.21	54.54
12 ..	May 20	37	$73\frac{1}{8}$	93	2	96	3	39	51	3.12	41.93	54.95
	Total ...	359	.....	732	.....	.....	178	232	322	.....	.....	.....
	Average	.....	21.25	.....	1.45	54	.....	.....	.....	27.12	32.05	40.89

Poison sifted from a sack.—Five tests (Table I, Nos. 6, 7, 8, 9, 10) were made at Victoria on seppa plants without squares. In tests 8, 9, and 10 the plants were sprayed lightly to give dew conditions. The total number of weevils used was 371, and the average time before making the last examination was $42\frac{1}{2}$ hours. The number of live weevils found was 24.69 per cent and the dead 25.33 per cent of the total number treated, while 49.69 per cent were missing. In three of the tests the exact amount of poison used is recorded and was at the rate of 20, 33, and 45 pounds per acre, respectively, where plants are 2 by 4 feet apart.

Two tests (Table I, Nos. 11, 12) were made upon seppa plants bearing squares. In one test with 95 weevils on 39 plants the last examination, made at the end of 96 hours, showed 21.87 per cent alive, 24.21 per cent dead, and 54.54 per cent missing. Poison was used at the rate of 41 pounds per acre. The second test was made upon 93 weevils on 38 plants. At the last examination at the end of 96 hours 3.12 per cent were alive, 41.93 per cent dead, and 54.95 per cent missing. The rate of poison used was 73 pounds per acre. Wherever the poison was applied so heavily the plants were very badly injured.

These results are abundantly corroborated by Professor Sanderson, who states:

> We have made similar experiments with over 500 weevils and were unable to find over 30 per cent dead at the end of 4 or 5 days, while an average of about 9 per cent were found alive at the end of 5 days. The balance of over 60 per cent were missing.

About 10 per cent of the marked weevils recorded as missing upon examinations of treated plants were subsequently found alive upon other plants. A careful series of tests has shown that weevils are incapable of flight after having eaten Paris green. It has also been found that on the average one ten-thousandth of a grain constitutes a fatal dose. It would appear fairly certain, therefore, that nearly all of the missing weevils really escaped alive. If so, then the number of weevils actually found dead approaches very closely to the total number killed, while the number found alive is really less than one-half of those that actually escaped. The period of the emergence of the weevils from hibernating quarters is known to extend over from 6 to 10 weeks, so that at least four applications of poison would be necessary to keep the cotton poisoned thoroughly enough to kill as large a percentage of weevils as was killed in the foregoing tests.

Summary.—Summarizing all of the tests with dry Paris green on small areas gives a total of 732 weevils used. The average time between treatment and last examination was 54 hours. An average of 27.12 per cent of the weevils were found alive, 32.05 per cent dead, and 40.89 per cent missing. The lightest application of poison was 20 pounds per acre, and four applications at this rate could not possibly be profitable, especially since the last applications would be after the cotton had squares, and the number of weevils the poison would kill would be greatly reduced.

No tests were made with very light applications, but the following experiments made on the Government farms and by individuals show the inefficiency of Paris green where the poison was applied at a rate of 1½ to 3 pounds per acre for each application and used throughout the season.

TREATMENT OF LARGE AREAS DURING SEASON OF 1904.

Three experiments were conducted by this Bureau at different places, using Paris green on one plat and making frequent applications throughout the season, keeping an adjoining plat as a check, both plats being planted at the same time with the same kind of seed and both cultivated exactly alike.

Field experiments at San Antonio.—At San Antonio a field of 1.70 acres planted with King cotton was chosen. This field was comparatively isolated, there being no nearby cotton except on one side and this was separated from the test fields by a dense strip of sorghum 124

feet wide. One-half was kept as a check and, beginning when the first squares were formed, Paris green was applied by means of the sack-shaking method on the following dates:

	Pounds per acre.
June 10	1
June 16	1¼
June 24	1¼
July 5	1¼
July 15	1¼
August 1	1¼

From July 13 to August 3 examinations were made to ascertain the relative number of squares infested on the poisoned plat and its check. Blooming ceased before the first examination was made, and at practically the same time on both plats, so the table does not show the relative infestation while blooming was in progress, but it does show most conclusively that the poison did not kill enough weevils to allow the treated plat to keep on blooming and producing bolls after the untreated check had stopped blooming.

TABLE II.—*Examinations of Paris-green experiment, San Antonio, Tex.*

Plat.	Date examined.	Number of squares examined.	Number infested.	Per cent infested.	Number of small bolls examined.	Number of small bolls infested.	Per cent of small bolls infested.
Paris green	July 13	78	70	89.74	3	3	100.0
Check	....do...	93	87	93.54	0	0	0
Paris green	July 27	91	76	83.51	5	2	40.0
Check	....do...	90	78	86.66	8	3	37.5
Paris green	Aug. 3	88	85	96.59	10	3	30.0
Check	....do...	69	61	88.40	10	4	40.0

An average of all examinations on Paris-green plat shows 89.94 per cent infested and on the check 89.53 per cent. The fact that the percentages are almost identical shows that the poison had practically no effect.

The poisoned area yielded 190 pounds and the check 93 pounds of seed cotton, an increase on the poisoned plat of 97 pounds, which would be a gain of 113 pounds per acre. The cost of poisoning was about $1.80 per acre, so that, making no allowances for the circumstances noted in the following paragraph, the net gain was only about $2.15 per acre, reckoning seed cotton at 3½ cents per pound.

Running diagonally across the poisoned plat was an old road, the presence of which was not known when the experiment was planned. This road touches only one corner of the check plat. Along the location of this old road the cotton grew very rankly and produced much more abundantly than did the adjacent portions of the field. Making an allowance for the increased production on the Paris-green treated

plat due to this old road, it will be seen that the real increase, if any, due to the treatment would not have paid for its application. It did not lengthen the period of blooming, increase the number of blooms, or produce any marked increase in the yield.

Field experiments at Mexia.—A field of 1½ acres in the form of a right-angled triangle was divided into a 1-acre plat for poisoning and a one-half acre plat for check. On one side of the field, but separated from it by a gully 20 yards wide, was another cotton field; the other two sides were adjacent to a peach orchard and to farm buildings. Beginning immediately after the first chopping an application of Paris green of 1 pound per acre was made from a sack on each of the following dates: May 16, 24, June 8, 29, July 8, August 4. From July 30 to September 13 five examinations were made to determine the relative number of squares infested on the poisoned plat and on the check.

TABLE III.—*Examinations of Paris-green experiment, Mexia, Tex.*

Plat.	Date examined.	Number of squares examined.	Number infested.	Per cent infested.	Number of small bolls examined.	Number of small bolls infested.	Per cent of small bolls infested.
Paris green	July 30	58	50	86.2	31	25	80.0
Check	....do...	60	52	86.6	20	16	80.0
Paris green	Aug. 9	28	24	85.7	62	52	83.8
Check	....do...	22	19	86.4	43	37	86.3
Paris green	Aug. 16	10	10	100.0	40	39	97.5
Check	....do...	12	12	100.0	50	50	100.0
Paris green	Aug. 29	80	72	90.0	18	18	100.0
Check	....do...	77	74	96.1	42	42	100.0
Paris green	Sept. 13	134	125	93.1	12	11	91.6
Check	....do...	102	94	92.1	16	16	100.0

An average of these five examinations shows that on the Paris-green plat 91 per cent and on the check 92.2 per cent of the squares were infested. The fact that the percentages are almost identical shows that the poison had no effect, and this conclusion is borne out by the yield. The poisoned plats produced 270 pounds of seed cotton, while the check, which is only one-half the size of the poisoned area, gave 200 pounds, or an excess of 50 per cent over the poisoned area.

Field experiments at Calvert.—An isolated 5-acre field was divided so that one-half of it served as a check. The entire field was planted during the third week in March, but growth was delayed by unfavorable weather conditions. Beginning immediately after the first chopping, May 26, applications of 1 pound of poison per acre were made every seven days. Fifteen applications were made in all, the last being on August 31. The cost of the poison used was $6.20 and the labor $10.80, making a total of $17. The method of applying the poison

was the usual method of sifting from a sack. Early in the season three examinations were made of lots of ten plants in each plat to determine the number of weevils.

TABLE IV.—*Number of adult weevils found, Paris-green experiment, Calvert, Tex.*

Plat.	Date.	Number of weevils.
Paris green	July 21	0
Check	...do....	0
Paris green	Aug. 4	0
Check	...do....	0
Paris green	Aug. 15	16
Check	...do....	18

Later two examinations were made to determine the relative numbers of infested and uninfested squares and bolls.

TABLE V.—*Infestation of squares and bolls, Paris-green experiment, Calvert, Tex.*

Plat.	Date examined.	Number of squares examined.	Number infested.	Per cent infested.	Number of small bolls examined.	Number of small bolls infested.	Per cent of small bolls infested.
Paris green	Aug. 23	128	124	97.7	80	3	2.3
Check	...do....	133	119	90.0	95	5	3.8
Paris green	Sept. 9	141	131	92.9	30	30	100.0
Check	...do....	102	97	95.0	34	33	97.0

These examinations show only a very slight difference in percentages of infestation, which was in all cases so great as to prevent flowering. It will be seen that the poisoning had no appreciable effect.

The poisoned plat yielded 1,217 pounds of seed cotton and the check 1,070 pounds, which is an excess of 147 pounds for the poisoned plat. Reckoning seed cotton at 3½ cents per pound there was a gain of $5.15. The total cost of poison and labor was $17, making a loss of $11.85, or $4.74 per acre.

EXPERIMENTS CONDUCTED BY VARIOUS PLANTERS.

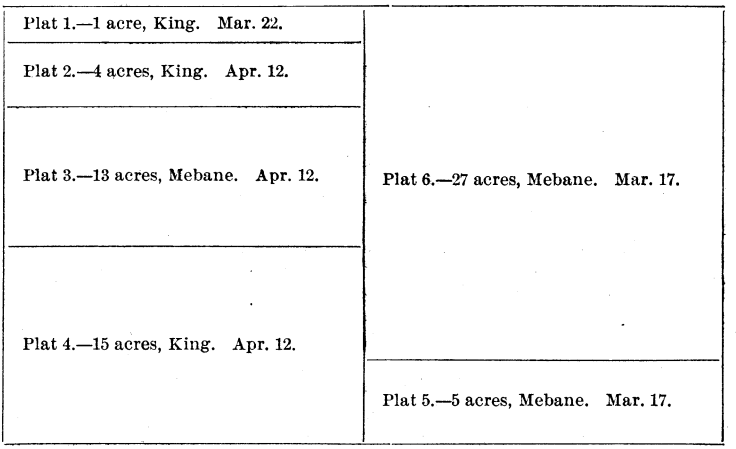
Mr. J. C. Houston, Floresville.

The 2-acre field poisoned was isolated. There was a road on one side, pastures on two sides, and a house on the fourth side. The cotton was seppa and received five applications of poison at the rate of 1½ pounds per acre, in addition to which one-half of the field had a further application of 3 pounds. All applications were made before June 1 and by the sack-shaking method.

On June 9 an examination of this field showed that 30 per cent of the squares were infested, and on July 2, when 71 per cent were

infested, the field had stopped blooming. Weevils were so numerous at that time that there was no chance of further formation of bolls. As the yield was somewhat less than 250 pounds of seed cotton per acre, it can not be considered that the use of poison was successful.

Mr. W. Withers, Lockhart.



The above sketch, with the exception of plat 6, represents the fields which were poisoned once by means of a powder gun at the rate of 2 pounds per acre. With the following exceptions, the fields were all cultivated exactly alike, each being plowed nine times. Plat 1 was broken four times, as follows: In July, in August, and in September, 1903, and in February, 1904. The other fields were broken only in the spring, when plat 3 was double bedded, while plats 5 and 6 were single bedded.

The yield upon plat 6, which was not poisoned, as well as upon the remainder of the plantation, averaged about one-half bale per acre. On plat 5 the yield was about the same; plat 3 gave three-fifths bale per acre; plats 2 and 4 about 340 pounds of lint per acre, while plat 1 produced over two bales. In other words, plat 5 was no better than cotton which was not poisoned, while plat 3, which was double bedded, was better than either plat 5 or cotton which was not poisoned. This difference in yield can be attributed only to the better preparation of the land before planting, for plat 3 was planted nearly a month later than plat 5. The value of thorough preparation of the land before planting is more strikingly shown in the contrast between plats 1 and 4. Plat 1, while only 1 acre in area, was thoroughly broken four times before planting and produced over two bales, while plat 4 with one spring breaking produced less than four-fifths bale per acre.

Mr. Withers also poisoned a 5-acre field six times at the rate of 2 pounds per acre for each application and this field did not produce as

much as did fields which were not poisoned. When these facts are considered it becomes evident that the increase in production in the plats mentioned above was largely the result of increased cultivation rather than the result of poisoning.

Mr. J. Zachary, Lockhart.

At one end of a 10-acre field on the plantation of Mr. Zachary about 30 rows were poisoned from six to eight times by Capt. B. W. Marston; the rest of the field was used as a check. Otherwise conditions were the same in the two plats, each having been planted at the same time and with the same variety of seed. Mr. Zachary states that the check produced more per acre than did that part of the field which was poisoned.

In addition to the 30 rows treated by Captain Marston, Mr. Zachary himself poisoned some cotton, treating it about five times. In this experiment also the nonpoisoned cotton was the better.

Mr. J. T. Shanks, Cuero.

The area poisoned was in the open field with a road on one side and cotton on the other three sides. The fields were planted early in March and were thoroughly worked. Plats of King and native varieties were poisoned by dusting from a sack. The King cotton was poisoned five times at the rate of 1 pound per acre for each of the first three applications and 2½ pounds each for the last two. The native cotton adjoining the King was poisoned four times at the same rates. Near by this plat was native cotton poisoned three times and also some poisoned only twice.

The King cotton produced about one-half bale per acre. The native cotton poisoned four times produced about the same. The other cotton poisoned did not show any difference in yield between that poisoned twice and that poisoned three times, nor any material difference over cotton not poisoned. As there was no check for the King cotton, there is no way of telling whether that variety was benefited by the poisoning. But in the native cotton the fact that cotton poisoned twice or three times did not show an increase in production over cotton not poisoned at all indicates that the greater production by the part poisoned four times may have been due to some other agency than Paris green. According to a recent statement made by Mr. Shanks in the presence of the writer (November 26, 1904), there were two neighboring fields planted upon exactly the same kind of soil which were not poisoned, but which produced as much cotton per acre as did the field in question. There is, therefore, no doubt that this experiment is absolutely inconclusive.

Mr. W. D. Keyser, Marlin.

These fields were visited on September 9 by Mr. G. H. Harris, who reports as follows: Mr. Keyser had twice poisoned a 24-acre block at the rate of 2½ pounds per acre. The adjoining nonpoisoned field appeared to be equally well fruited, but no blooms were seen in either field.

Another 20-acre field was poisoned twice with a half pound per acre at each application. The adjoining field, though not poisoned, appeared to be equally as good.

In another field one part was poisoned twice with 1 pound per acre, one part four times with 1½ pounds per acre, and the balance was not poisoned. No difference was found in the number of bolls or blooms on the plants counted, and as many weevils were found in one part as in another.

The fact that Mr. Keyser's crop is better this year than heretofore is due to the fact that this year he has planted improved seed—King and Indian Territory mainly. Other near-by fields were seen which, while not poisoned, were as good or even better than Mr. Keyser's poisoned fields.

Rev. J. M. Purcell, Lockhart.

All of the cotton used in the following experiments was planted in rows 40 inches apart, with plants 2 feet apart in the drill. All fields were plowed four times. All were poisoned four times by means of a powder gun at intervals of ten days. The first application was made on July 18 and the rates of application were 2, 2, 2, and 6 pounds per acre. Each of the four experiments had an adequate check. In two of the tests the poison was applied early in the morning while the plants were still wet with dew, and in the other two the poison was put on after the plants had become entirely dry, the theory being that the poison would enter the involucres of the bolls and squares.

The first field, about 2½ acres in area, was located on a hillside and the part poisoned was a triangular piece of one-half acre. This field was planted early in March with native seed, but replanted after being cut down by hail on May 16. To this field the poison was applied while the plants were dry and the yield was nearly 700 pounds of seed cotton, while the check produced almost nothing.

All of the following fields were entirely cut down by the hail on May 16 and were replanted with common native seed about May 30. The cotton was about waist high when first poisoned.

The second field was located on bottom land with woods and creek on two sides, the land sloping upward and away from the creek to the northward and at this end of the field was the check; the southern end of the field was 1 acre in area and was poisoned when the plants

were dry; lying between this and the check was one-half acre separated from these two plats by strips 30 feet wide, and to this area the poison was applied while the dew was on the plants.

The yield of the 1-acre field, poisoned when the plants were dry, was nearly 1,000 pounds of seed cotton. The field poisoned while wet with dew gave about enough to pay for the cost of the poison, while the check produced almost nothing.

The other field, which was poisoned while wet with dew, was also on bottom land with woods and a creek on one side and corn on one side, the nearest cotton being about 100 yards away. The area of this field was about 14 acres and the part poisoned was in the center of the field. The result of this test is identical with the other test in which the cotton was poisoned while wet; that is, the yield will about pay for the cost of the poison.

These results show failure in both tests where the usual method was followed of applying the poison when the dew was on the plants, while both those tests in which the poison was applied when the plants were dry were apparently successful. These are the only instances of even apparently successful use of Paris green known to the writer. When considered in connection with the great number of unquestionable failures, it would seem that some other agency than the poison may have been responsible for this apparent success. Mr. Purcell is not inclined to accept the results as a conclusive demonstration of success in poisoning while the plants are dry and says that the experiments must be repeated next season to prove an actual demonstration.

Planters at Hearne.

A number of large planters living around Hearne poisoned all of their cotton two or three times this season for the leaf worm, but they are unanimous in stating that it is ineffective against the boll weevil. Among those who have used Paris green extensively may be mentioned Mr. C. G. Woods, who poisoned a 20-acre field five times, using $2\frac{1}{2}$ pounds per acre at each treatment, the first application being made when the cotton began to square. The yield of this field was no better than that of fields which were not poisoned. Mr. Woods also poisoned about 300 acres twice during May and June at about the same rate as above, but says that the yield is no better than that of other cotton which was not poisoned.

Col. R. J. White poisoned over 2,000 acres three times for leaf worm, beginning about July 20, and using $1\frac{1}{2}$ pounds per acre at each application. He says that the poisoned cotton has yielded no better than cotton on similar lands which was not poisoned, and that Paris green is of no use in fighting the weevil. The tendency in this locality is to drop poison entirely, for in the presence of the boll weevil the

leaf worm is considered a friend instead of an enemy, and planters who have several thousand pounds of poison on hand at the present time declare that they will not use another pound of it.

SOME REASONS FOR APPARENT EFFECTIVENESS OF PARIS GREEN.

There are several circumstances which have led some users of Paris green during the growing season to conclude that the applications of poison were effectual, but upon closer examination it may be seen that these appearances depend upon other causes than the application of poison. The active life of the hibernated weevil may extend over from 60 to 80 days, so that during the latter part of May and during June a majority of the weevils which lived through the winter, having by that time deposited their eggs, are dying naturally, and these dead weevils being found in the poisoned fields have given the impression that they were killed by the Paris green. A good illustration of the dying of hibernated weevils was seen in a field of Mr. José Cassiano, San Antonio, Tex., who found many dead weevils in a field early in June, and concluded that ants were killing them. An examination showed that the ants were simply carrying off weevils which had died. Others have reported that after poisoning their fields they have found as many dead weevils in the part not poisoned as in that to which poison was applied. At Runge the business men made the following test before deciding whether they should recommend the use of Paris green: Two plants were placed under screens, one poisoned and one not poisoned, and upon each of these plants was placed the same number of weevils. They found that as many weevils died on the plant which was not poisoned as upon that which was poisoned.

Another apparent reason results from the condition called "spotted crop," which has been very common this year. One field where there is no apparent reason for such condition will show a good crop on some parts of the field while other parts will have nothing, and this unevenness exists without regard to the poisoning of the field. If it should happen that the poisoned part should produce the best crop, the owner would naturally conclude that the poison was the effective cause. As happened in several instances, however, the part of the field naturally inclined to produce a poorer crop was poisoned and produced very little, while the nonpoisoned portion of the field yielded a much better crop.

In many cases where poison was applied the farmer provided no adequate check upon the poisoned area. In such cases there is no way of telling how much or how little effect the poison had. The owner

might conclude that the field to which he applied poison yielded much better than it would have done if not poisoned, whereas his neighbors who did not use poison could frequently show as good or even better crops than the man using poison.

It is an unquestionable fact that many persons are very responsive to suggestions. A patient having taken medicine expects to improve, and may recover if the remedy applied were not injurious, even if it were not helpful. In the same way a planter, having applied what appeals to his mind as a remedy for the boll weevil, will expect beneficial effects to follow the application. He will look then for, and probably find, dead weevils, many of which died a natural death. He will examine the plants with care, and as the hibernated weevils die off in numbers, while the development of their progeny is slow and gradual, he will notice what is frequently, if not generally, the real condition, that from the middle to the last of June, or, more exactly, from four to six weeks after the first squares become about half grown, fewer adult weevils are to be found in the field than could be found when squaring began. Then again the rapidly increasing number of squares so greatly decreases the proportional number of weevils that it seems that weevils have almost entirely disappeared. When the cotton opens the user of poison is likely to think that he can see a marked difference in favor of the treated cotton. As an example of this may be mentioned two fields in Cuero, one of which was poisoned twice and one three times. When the cotton was opening the owner stated that there was a distinct gradation between the cotton not poisoned, that poisoned twice, and that poisoned three times, but upon picking he found that there was practically no difference in the yield under the three conditions. Other instances of this tendency could be given.

The difficulty of estimating the quantity of cotton a field will yield often leads to wild predictions on this point, whereas picking weights show that there was little or no difference. Of the planters whose experiments have been reported in this bulletin, it will be noticed that many who used poison on their plantations invariably applied it to the improved varieties, if they had planted any such varieties. Messrs. Zachary, Purcell, and the planters at Hearne did not plant King or Territory seed, while the others did. Mr. Houston poisoned a field of seppa cotton situated in town. The application of the poison to improved varieties was in a large measure responsible for the apparent success of the poison treatment. As a matter of fact these varieties invariably yield more than native cottons without any special attention whatever.

Another important error has been due to the fact that early applications of Paris green have prevented defoliation by the caterpillars. Consequently, many poisoned areas have had the appearance of yielding

much better than untreated ones, though this appearance is altogether deceptive, and due to the uninterrupted growth of the plants treated.

However, the greatest source of error has been the one mentioned in the introduction, namely, that the destruction of the few weevils found upon the plants before any squares have been set represents but a small fraction of the total number that will later emerge from hibernating quarters to damage the crop. That the number found early in the season is but a small portion of the whole, is shown by the following table:

TABLE VI.—*Gradual emergence of weevils from hibernation at Victoria, Tex.*

Date collected.	Number of weevils taken.	Per cent of total number taken.	Date collected.	Number of weevils taken.	Per cent of total number taken.
1904.			1904.		
Mar. 18	19	2.72	Apr. 26	15	2.14
Mar. 25	20	2.86	May 1	24	3.43
Mar. 31	76	10.88	May 11	152	21.77
Apr. 5	35	5.01	May 17	95	13.60
Apr. 12	60	8.59	May 19	60	8.59
Apr. 16	40	5.73	May 21-24	102	14.61

The above table records 12 examinations, in which 698 weevils were taken. Of this number 37.96 were collected before May 1 and 62.04 after that date. The plants began to put on squares numerously about May 1. These hibernated weevils were collected from seppa plants scattered over 4½ acres of ground planted with cotton in 1903. The block examined was surrounded on three sides by cotton ground and on the fourth side bounded by a road. All seppa cotton on the surrounding area was kept down, so that there was no chance of any breeding, and no other fields were near enough for weevils to have come from them. All the plants were examined and the weevils collected to prevent the recounting of weevils. In Table VI the total number of weevils collected is called 100 per cent, although the large number taken at the last examination shows that even then many weevils were still coming out of hibernation.

An impression equally as mistaken as that all hibernated weevils emerge at the same time is that the boll weevil moves from the squares at night to feed upon the dewdrops upon the leaves. Abundant observation has shown that the insect moves very little at night, being almost entirely diurnal.

CONCLUSION.

Repeated tests have shown that about 30 per cent of the weevils on the plants may be killed by a heavy application of poison when the plants are small and without squares. But since the gradual emergence of weevils from hibernation extends over a period of from six to ten

weeks, so that it continues long after squares have formed, the killing of 30 per cent at the time squares begin to form means really but a very small percentage of the total number of hibernated weevils. Continuous use of poison throughout the season on the Government farms has not shown any gain from the use of poison. The tests made by individuals have, as a whole, failed, there being only one instance of apparent success in contrast to the great number of admitted failures. Even where apparently successful the results were mainly due to the yield from improved seed being contrasted with that from native seed. The greatest apparent success was in the field of Mr. W. Withers, Lockhart, Tex., where the land was repeatedly broken prior to planting, and King seed was planted early, followed by thorough cultivation. This plat yielded immensely superior results over other plats in which the same variety of seed was planted later on land not so thoroughly prepared. *No instance could show more strikingly the failure in the use of Paris green, and at the same time emphasize more conclusively the efficiency of the cultural method.*

SUMMARY.

From the rather extensive observations and experiments noted on the preceding pages the Bureau of Entomology concludes that the use of Paris green in controlling the boll weevil is absolutely futile. This conclusion is based upon the following determined facts:

I. Persistent use of Paris green from the time of chopping until picking (in some cases as many as 15 applications) has failed to materially reduce the numbers of the weevils or to increase the yield.

II. Careful examination of very many experiments with the poison made by planters in Texas has failed to reveal conclusive instances of its successful use.

III. Reasons for the impossibility of poisoning weevils successfully are to be found in the facts that only a very small percentage emerge from hibernation before the squares are set upon the plants, that they do not drink the dew on the leaves at night, and that as soon as squares are set all feeding is done within the shelter of the bracts (shuck) beyond the reach of any poison that might be applied.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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